APPENDIX C

PRESSURE COMPUTATION EXAMPLES

(1) Example 1 (for a dry hole)

Problem: Compute maximum allowable gage pressure.

Given: Maximum allowable pressure is 1-1/2 pounds per square inch per foot of depth. Grout mix is neat cement grout, w/c ratio is 1.0, and packer is set at depth of 100 feet. (Note: 1-1/2 psi maximum allowable pressure is used only as an example. Actual pressures are site dependent.)

Solution: 1-1/2 cubic feet of w/c 1.0 grout weighs 62.4 + 94 = 156.4 pounds. (Note: One 94-pound sack of cement = 1/2 cubic foot of solids.) 1 cubic foot of w/c 1.0 grout weighs 156.4/(2/3) = 104 pounds.

Pressure per foot exerted by w/c 1.0 grout = 104/144 = 0.72 pounds per square inch.

Maximum allowable pressure = 1.5 × 100 = 150 pounds per square inch.

Grout column pressure = 100 × 0.72 = 72 pounds per square inch.

Maximum allowable gage pressure = maximum allowable pressure minus grout column pressure = 150 - 72 = 78 psi.

General Information:

Specific gravity of cement = 3.15 (1 bag = 94 pounds) (1 bag = 1 cubic foot)

Specific gravity of water = 1.0 (1 cubic foot water = 62.4 pounds)

Specific gravity of bentonite = 2.50

Specific gravity of fly ash = 2.50

Specific gravity of sand = 2.65 ± (1 cubic foot sand ≃ 100 pounds)

Volume of solids in 1 cubic foot cement ≅ 0.5 cubic foot (actual is 0.479 if specific gravity is 3.15)

Volume of solids in 1 cubic foot sand ≅ 0.6 cubic foot

Column of water or slurry pressure per foot = $wt/ft^3 \times 1$ ft = wt/ft^3 = wt/144 = pounds per square inch

for water = 62.4/144 psi = 0.43 pounds per square inch

for 1:1 grout (above water table) = (62.4 + 94)/(1.5 × 144)
= 0.724 pounds per square inch

for 1:1 grout (submerged) = (62.4 + 94)/(1.5 × 144) - (62.4/144)
= 0.294 pounds per square inch

(2) Example 2 (for a wethole)

Problem: Compute maximum allowable gage pressure

Given: Maximum allowable pressure is 1 pound per square inch per foot of depth. Grout mix is neat cement grout, w/c ratio is 1.0, and packer is set at depth of 100 feet.

Solution: Artesian pressure to be overcome
= (120 ft × 62.4 lb/ft)/(144 $in.^2/ft^2$) = 52 pounds per square inch

Pressure exerted by grout column:

2-1/2 cubic feet of 2.0 grout weighs 2 × 62.4 + 94 pounds = 218.8 pounds

1 cubic foot of 2.0 grout weighs 218.8/2.5 = 87.6 pounds

Submerged weight of 1 cubic foot of 2.0 grout weighs 87.6 - 62.4
= 25.2 pounds

Pressure/foot of submerged 2.0 grout = 25.1/144 = 0.174 pound per square inch

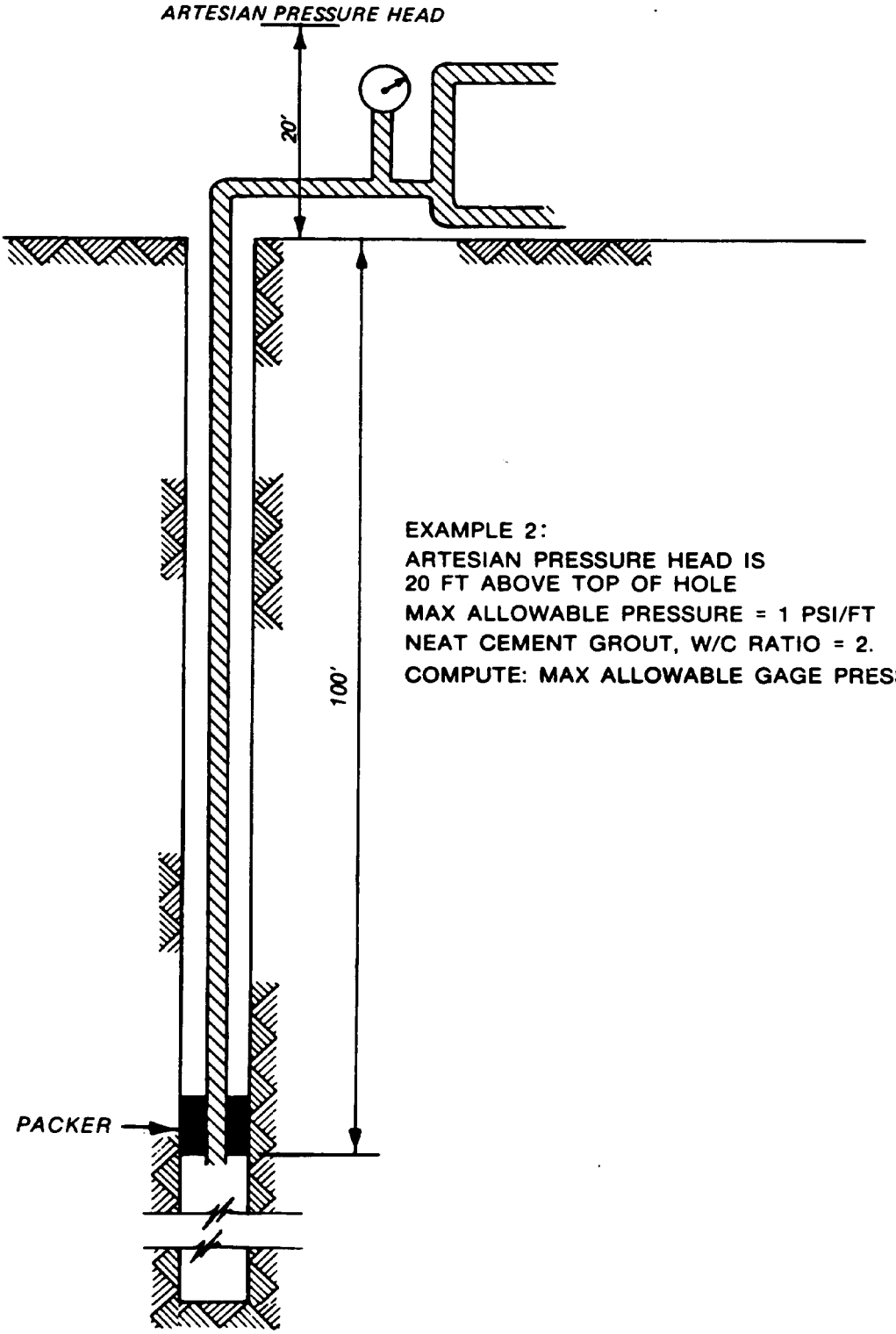
Pressure of 100-foot grout column = 17.4 pounds per square inch

Maximum allowable pressure = 1.0 × 100 = 100 pounds per square inch

Maximum allowable gage pressure = maximum allowable pressure + artesian pressure - grout column pressure

Maximum allowable gage pressure = 100 + 52 - 17.4 = 134.6 pounds per square inch

Figure for Example 2



(3) Example 3 (water table situation--see figure for Example 3)

Problem: Compute maximum allowable gage pressure

Given: Maximum allowable pressure is 1-1/2 pounds per square inch per foot of depth. Grout mix is 1 part water, 1 part cement, and 3 parts sand; weight of sand is 100 pounds per cubic foot.

Solution: Weight of mix (1:1:3) = 62.4 + 94 + 3 × 100 = 456.4 pounds

Volume of mix = 1 + 0.5 + 3 × 0.6 = 3.3 cubic feet

Weight of grout/cubic feet = 456.4/3.3 = 138.3 pounds

Pressure exerted by grout column:

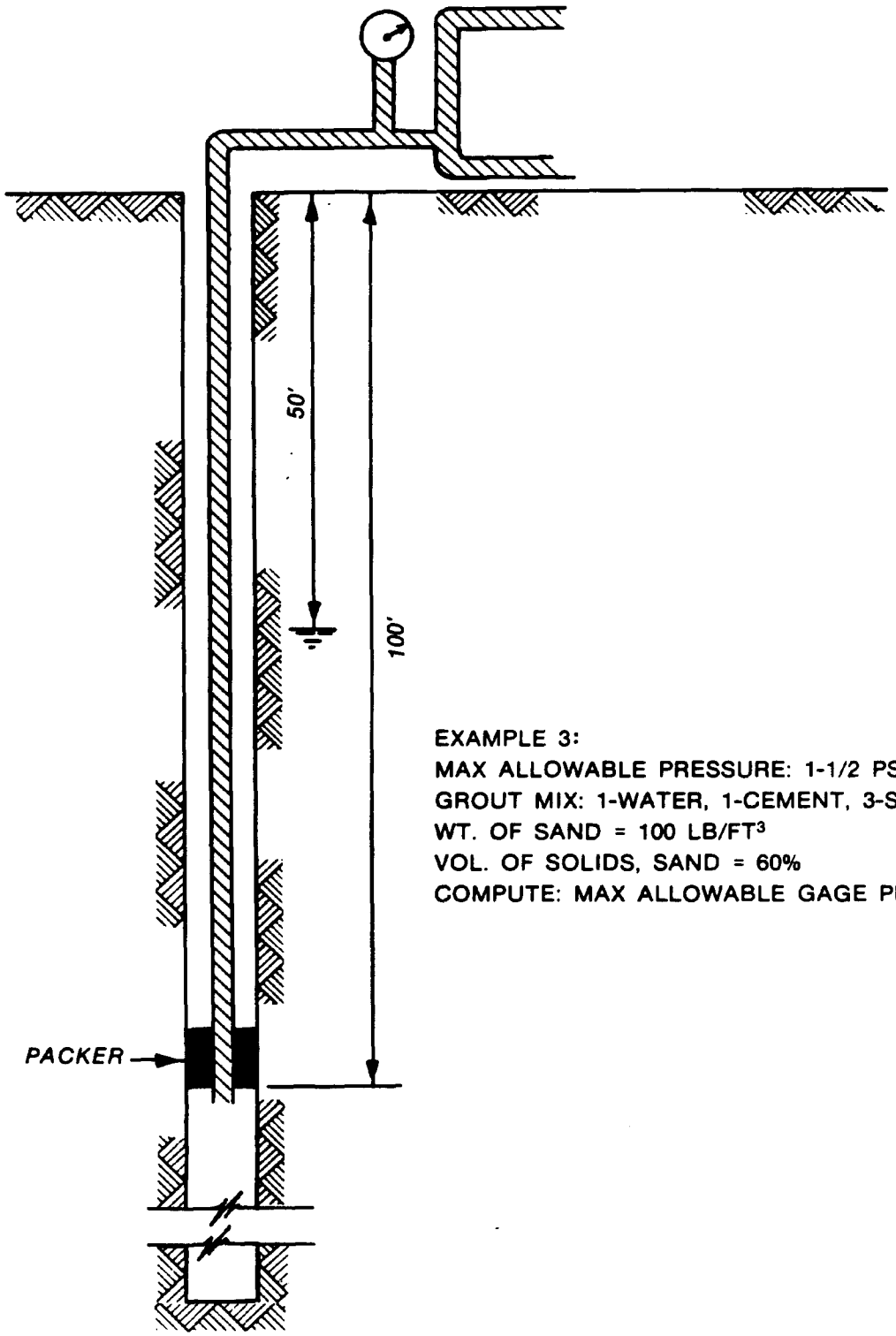
Above water table: 138.3/144 × 50 feet = 48.0 pounds per square inch

Below water table: [(138.3 - 62.4)/144] × 50 feet = 26.4 pounds per square inch
48.0 + 26.4 = 74.4 pounds per square inch

Maximum allowable gage pressure = maximum allowable pressure - grout column pressure

Maximum allowable gage pressure = (1.5 × 100) - 74.4 = 75.6 pounds per square inch

Figure for Example 3



EXAMPLE 3:
MAX ALLOWABLE PRESSURE: 1-1/2 PSI/FT
GROUT MIX: 1-WATER, 1-CEMENT, 3-SAND
WT. OF SAND = 100 LB/FT^3
VOL. OF SOLIDS, SAND = 60%
COMPUTE: MAX ALLOWABLE GAGE PRESSURE

(4) Example 4.

Rock is thinly bedded limestone with numerous bedding plane joints and shale partings.

Unit weight of rock γ_{rock} = 162 pounds per cubic foot

(a) What is recommended maximum grouting pressure?

Solution: 162/144 = 1.125 pounds per square inch per foot of depth

(b) If water table is at 50 feet and the packer is set at 50 feet, what is recommended gage pressure range?

Anticipated grout mix is cement grout, and water cement ratios may vary from 6.0 to 1.0.

Solution: For 1.0 grout, gage pressure = 1.125 - (62.4 + 94)/(1.5 × 144)
= 0.4 pound per square inch per foot

For 6.0 grout, gage pressure = 1.125 - (6 × 62.4 + 94)/(6.5 × 144)
= 0.5 pound per square inch per foot

At 50-foot depth, the range would be from 0.4 × 50 to 0.5 × 50, or 20 to 25 pounds per square inch